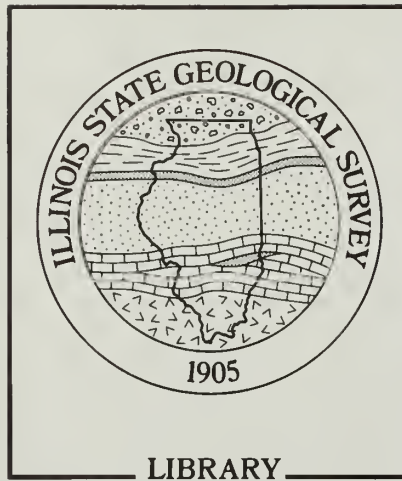


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Geol Survey

Illinois State Geological Survey's Efforts Toward a Better Economy and a Healthier Environment





Cover photo: Beginning millions of years ago, lower Pennsylvanian sandstone blocks have crept downhill across the underlying slick shale.

From the Chief

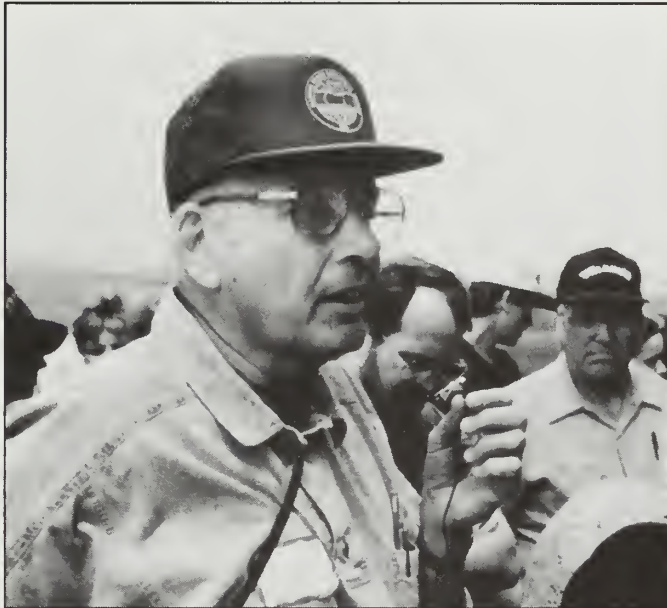
"We have unmistakable evidence that this state is scarcely excelled in the extent of mineral riches, and all that seems to be wanting to render them richly productive is to point attention to them. As some considerable time will be required for a careful and minute geological survey of the whole state, I would respectfully suggest whether its importance would not justify a limited appropriation, to be followed by others thereafter, as the results and prospects of success might render desirable." With these words, Illinois' governor in 1851 moved the General Assembly to approve a bill authorizing the employment of a geologist to make a geological and mineralogical survey of the state.

The message delivered in 1851 and down through the years has not changed: Illinois is wealthy in its many mineral resources; geology is necessary to locate and develop them in an economically yet environmentally sound way; and the Illinois State Geological Survey (ISGS), a division of the Department of Energy and Natural Resources, has delivered and continues to deliver significant results and offers prospects of continued success in the application of geology to help resolve state and national issues.

This past year, for example, despite enduring major disruptions, including threats of restructuring within state government and severe budget cuts, the ISGS

achieved a proud record of accomplishments in its efforts to promote sound economic development and environmental protection in Illinois. The Survey continued to serve the public, private and governmental sectors not only as a research and service institution, providing credible, unbiased science and technology, but also as an informational agency on the state's natural resources.

Its programs in coal, oil and gas, minerals, and groundwater resources contributed directly to Illinois' economy. Resources for today and tomorrow were identified, and the state's potential for the future was estimated in a number of fuel and non-fuel mineral investigations. Information, ideas and incentives along with new technologies were introduced through a program of the ISGS aimed at helping to promote investment in Illinois and create jobs. During the year, the Survey introduced several technologies to encourage greater utilization of Illinois' coal. The ISGS' proprietary method for producing a super-sorbent, high-surface-area hydrated lime for removing sulfur dioxide during coal combustion was readied for pilot-plant scale up. Its program for improving oil recovery from existing reservoirs through reservoir characterization and better reservoir management received national recognition. And a six-year study was completed and released to industry on the undiscovered mineral potential of southern Illinois, stimulating queries,



*Morris W. Leighton
talks to participants on a
field trip.*

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interest and developmental activities in that area. The potential for new water supplies was identified for a number of rapidly expanding communities in the state.

A benefit/cost study was published, highlighting the value of geologic mapping to help site disposal facilities to avoid clean-up costs. A pay out for such mapping of up to 27:1 was recorded for Boone and Winnebago counties. Other efforts to protect the environment included a technical assistance program to counties to help site landfills; assistance to the Illinois Department of Transportation in identifying issues related to highway construction near wetlands in order to appropriately maintain, restore or replace them; and development of procedures to measure and monitor the movement of pesticides in groundwater. Inroads were made in identifying chemicals that could absorb and inhibit the movement of pesticides into the subsurface and the state's groundwater supplies.

Information on earth hazards resulting from on-going investigations were used to help protect Chicago's shoreline from erosion, locate sand supplies for beach replenishment, and provide guidance to those dealing with mine subsidence. Especially newsworthy this past spring was the Survey's assistance to industry and the Army Corps of Engineers on the nature of earth materials in which Chicago's flooded tunnels were located. The information on the nature of the surrounding clays supported the idea that the tunnels could be rapidly dewatered without affecting the foundations of buildings, thereby permitting rapid restoration of operations and return to work in what could have been a more costly disaster if the tunnels had been slowly dewatered. This situation was but one example of the use of the ISGS' vast data bases. It also served to demonstrate the manner in which the Survey can respond as a consequence of maintaining both a data base of earth-resource information and a trained cadre of scientists and engineers who know how to use and interpret the data base.

It seems abundantly clear that if ever there were a time for programs and projects in support of economic development and environmental protection, now is that time. Tremendous pressures exist on business and the environment. Yet, budget cuts, as serious as any cuts ever suffered by the ISGS, resulted at year's end, seriously affecting the FY93 budget and the Survey's ability to address issues of economic development and environmental protection. In contrast, during the Great Depression in the 1930s, support for the State Geological Survey remained strong, leading to increases in the face of adversity. The work of the ISGS was viewed as an investment in the economic development of Illinois. Added to that mission, which is still valid, is the goal to protect the environment. It is hoped that the wisdom of the '30s, leading to major successes in coal research, significant increases in production of oil from the Illinois Basin and jobs, will still hold for the '90s as the state struggles to right itself from the effects of a persistent and pervasive national recession.

This report, the fifth to be prepared especially for the general public, focuses on the ISGS' accomplishments, over time, aimed at promoting economic development and protecting the environment in Illinois. Also included are supportive words from those who have relied on the Survey for scientific knowledge, data and/or services, which proved to be helpful to and/or necessary for the success of their endeavors--whether economic or environmental in nature. Should you wish more comprehensive, technical information, I invite you to request a copy of the ISGS' scientific annual report.

Morris H. Lightner

Toward a Better Economy and a Healthier Environment

If ever there were a time for projects and programs to stimulate economic development, to create jobs, and to protect the environment, now is that time! The Illinois State Geological Survey (ISGS) has a proud record of achievement in stimulating efforts in these activities within the state. That record began in 1851 and was given fresh impetus in 1905, the year in which the General Assembly founded the present Illinois State Geological Survey, and continues today. From its inception, the ISGS was directed by the legislature to study, map and report on Illinois' mineral resources and its geology.

Over the years, many contributions have been made from the Survey's evolving research and development (R&D) program to aid the economy and the state's environmental health. Examples abound.

The examples cited here don't "just happen:" They result from a steady, long-term program of building a corps of experts in a given field, of maintaining and expanding the data base in that field over time, and of shifting emphases to take into account both new information and new challenges—indeed, shifting emphases in anticipation of new challenges—but doing so from a strong base of trained experts, knowledgeable about conditions in Illinois and with ready access to an ever-growing, well-organized and maintained data base. Let's look at a few of those examples.

Impacts from Coal Research and Development

Past After a number of years of painstaking effort to study and understand the nature and quality of Illinois' coal, in 1934, G. H. Cady, with the help of his fellow workers, was able to demonstrate why Illinois' coal should be classified as bituminous coal, not sub-bituminous, thereby ensuring its higher price for that year and all the years since, resulting in very large sums of income to Illinois' coal industry and to the tax base for the benefit of Illinois' citizens.

Since that time, using the growing expertise, enhanced facilities and data base, the Survey has had a broad spectrum of successes in coal R&D. Among them was the demonstration that certain Illinois coals could be used in coking coal blends. During World War II, the use of the state's coal reduced the need for railway freight cars to move coking coal from the Appalachian coal fields to the steel mills of the Midwest, thereby saving on transportation costs and freeing railway cars to help the war effort elsewhere.

Extensive work on the nature of coal deposits in Illinois led the Survey in the late 1960s and '70s to the conclusion that deposits of lower sulfur coal occur along ancient river channels under river-derived deposits of clay, silt and sand that protected the underlying peat deposits from sulfur-bearing sea water. The Sur-

Coke is being discharged from the moveable wall coke oven in 1953 at the Applied Research Laboratory.



vey's model has been used extensively by mining companies to find and delineate deposits of relatively low-sulfur coal. Several coal mines were opened in low-sulfur coal areas along mapped paleovalleys. The Survey has continued its mapping of coal resources, recently publishing on the Hornsby District of west-central Illinois, identifying an estimated resource of 1.17 billion tons of coal with a low-to-moderate-sulfur content at moderate depth.

Meanwhile, geologists at the ISGS recognized that the Illinois Basin Coal Field is subjected to a strong east-west compressive stress which causes ground failure in north-south entries of deep mines. Scientists at the ISGS were involved in developing a successful strategy, reorienting mine workings diagonally to the direction of stress to minimize expensive roof falls, increasing mine safety and reducing mining costs. This strategy is being employed in several mines.



Brenda Mehnert, geotechnical engineer in earth hazards and engineering geology, uses an acoustical bench to determine pulse velocities of compression and shear waves in rock. This work, carried out through the Illinois Mine Subsidence Research Program, is part of characterizing the overburden over a longwall panel of coal.

Current The Survey's coal effort is focused on two major issues: What is left as minable resources in the state, and what can be done to help protect and create markets for Illinois' coal in the face of increasing competition and mounting environmental concerns, including clean air regulations and the potential impact of carbon dioxide (CO₂) on global warming.

The ISGS has identified 180 billion tons of coal resources, while noting that only 50 billion tons have been classified as having a high potential for development. (Some 60 million tons were mined in 1991--a small portion of that classified as having a high potential for development.) Of the 10 billion tons of identified relatively low-sulfur coal in the state, about 3.7 billion tons have a high potential for development. Illinois' coal resources have been illustrated on a set of five statewide maps. The Survey's geologists point out that only a portion of these resources is currently minable, considering technological factors, social and environmental constraints, and current economics.

The percentage of the identified coal resources available for future development is unknown at this point.

A set of 26 representative quadrangles has been selected to study this issue. Preliminary results from the first of these quadrangles, the Middletown Quadrangle located just north of Springfield, indicate that for that area less than 60 percent of the total coal resources are available for mining and possibly less than 25 percent of the resources may actually be recoverable. Factors limiting the availability of coal in this study area include weak roof and floor rock, thin bedrock cover, unfavorable stripping ratios, thin coal, and surface features such as cemeteries and interstate highways.

To help mining productivity—a key factor in economic competitiveness, the ISGS is working with the U.S. Bureau of Mines, the University of Illinois, Southern Illinois University-Carbondale, and Northern Illinois University to find ways to maximize coal production from longwall and high-extraction-retreat mining, while preserving prime farmland and protecting overlying structures. Subsidence research is important to facilitate longwall mining, which, in turn, has higher productivity than



Before moving the equipment inside, David L. Moran, chemical engineer, left, and Jimmie D. Cooper, craftsman, perform shakedown tests on the process optimization unit that produces high-surface-area hydrated lime at the Applied Lab.

conventional extraction methods. Guidelines are resulting from the R&D effort, indicating the steps needed to maintain crop production and mitigate any problems related to longwall or high-extraction-retreat mining.

To maintain coal production and miners' jobs, research and technology must find ways to utilize Illinois' high-sulfur coal, which means removing enough sulfur to meet the 1995 and year 2000 regulations of the Clean Air Act. To meet the conditions of this act, several promising projects are under way.

In one, the ISGS has developed a nationally recognized sorbent with far more reactivity for absorbing sulfur dioxide (SO_2) than hydrated lime that is commercially available. The process, by which the high-surface-area hydrated lime (HSAHL) is produced, has been optimized in a batch, bench-scale reactor and evaluated as being both technically feasible and economically attractive. Pilot-scale tests, conducted under conditions typical of burning high-sulfur coals, have achieved up to 90 percent SO_2 capture in various dry sorbent injection systems, up to 70 percent more effective than commercial hydrates. These results are enough to bring Illinois' coals into compliance with goals of acid rain legislation for the year 2000. A continuous process is being used to generate data for the private sector to scale up the process to a commercial level.

Arthur Conn and Associates, Ltd. completed an economic analysis of the HSAHL process. Projected costs of the sorbent were estimated to be between \$10 to \$25 higher per ton than costs of commercially-produced hydrated lime. Based on those estimates, the costs of sulfur removal (\$ per ton SO_2) in dry sorbent injection systems is about \$186 for the HSAHL versus \$252 for the commercial hydrate, considering only the sorbent's cost, because less HSAHL is needed for the removal of sulfur dioxide. The ISGS calculated that depending on plant size—from

Minerals engineer Hank Ehrlinger monitors the 12-foot-tall Deister flotation column at the Applied Lab. With column flotation, waste material from coal preparation plants is fed in slurry form into this type of column. A mixture of tiny air bubbles, chemical reagents and water is added. The fine coal particles adhere to the air bubbles and rise to the top and are removed as a concentrate. The resulting coal slurry may be ideal for coal gasification.



100 to 500 megawatt, utilities burning high-sulfur Illinois coals could save from \$0.5 million to \$6 million per year on the cost of lime itself by using HSAHL instead of commercially-available hydrated lime.

From the perspective of a Pennsylvania-based mineral resource firm involved in the HSAHL project, its president said, "The Survey displayed a great degree of inventiveness and hard work to get [the project] to its present state. We anticipate that the pilot plant work will lead to a major limestone development project in Illinois, and the end use will certainly help your [Illinois'] high-sulfur-coal industry survive the Clean Air Act rules...."

Another area which may pay dividends for Illinois' high-sulfur coal is work being done by the Survey in flotation of fine coal from plant wastes. In a cooperative venture, the ISGS has been instrumental in introducing slurried high-sulfur coal from Illinois as a feedstock for a slurry-fed commercial gasification system wherein the heat rate or Btus required to generate a kilowatt hour from the concentrate ob-

tained from coal flotation is lower than that of raw coal or western coal, meaning a higher plant efficiency is possible with a slurry of Illinois' coal. In addition, the presence of sulfur in the coal has not been a detriment in the gasification technology because sulfur is recovered as elemental sulfur, which has a market.

In cooperation with Kerr-McGee Coal Company at its Galatia plant, the Survey has performed demonstration tests of a column flotation system for physically cleaning fine coal. Consistently, more than 90 percent of the original energy contained in the input material has been recovered, while 90 percent of the original ash and 55 percent of the original sulfur content were rejected. The performance of the 35-foot-tall, 30-inch-in-diameter column exceeds that of the subaeration flotation cells currently in use.

In yet another venture, the ISGS is using an integrated process that combines physical coal cleaning, mild gasification and char desulfurization to produce a low-cost, low-sulfur char from Illinois' high-sulfur coal. This program is geared to produce chars with SO₂ emissions at least 50 percent lower than those of the parent coals and which meet the 1995 emission standard of 2.5 pounds of sulfur dioxide

Keith C. Hackley, geochemist, looks at pellets of fine coal and calcium hydroxide (a sulfur-capturing sorbent) taken up to different temperatures and ashed to produce a readily transportable fuel that will burn in compliance with the Clean Air Act. This research could improve the marketability of coal currently disposed of because mechanized mining procedures leave it too fine to be transported.



per million Btu. Preliminary results suggest that under unoptimized conditions, sulfur dioxide emissions from the six coals processed were reduced more than 60 percent. With acceptable burning characteristics, this product could be an attractive alternative to switching or blending coal, both of which decrease the utilization of Illinois' coal. In addition, the low-sulfur char could be used by utilities that are unable to construct scrubbers because of cost or space limitations.

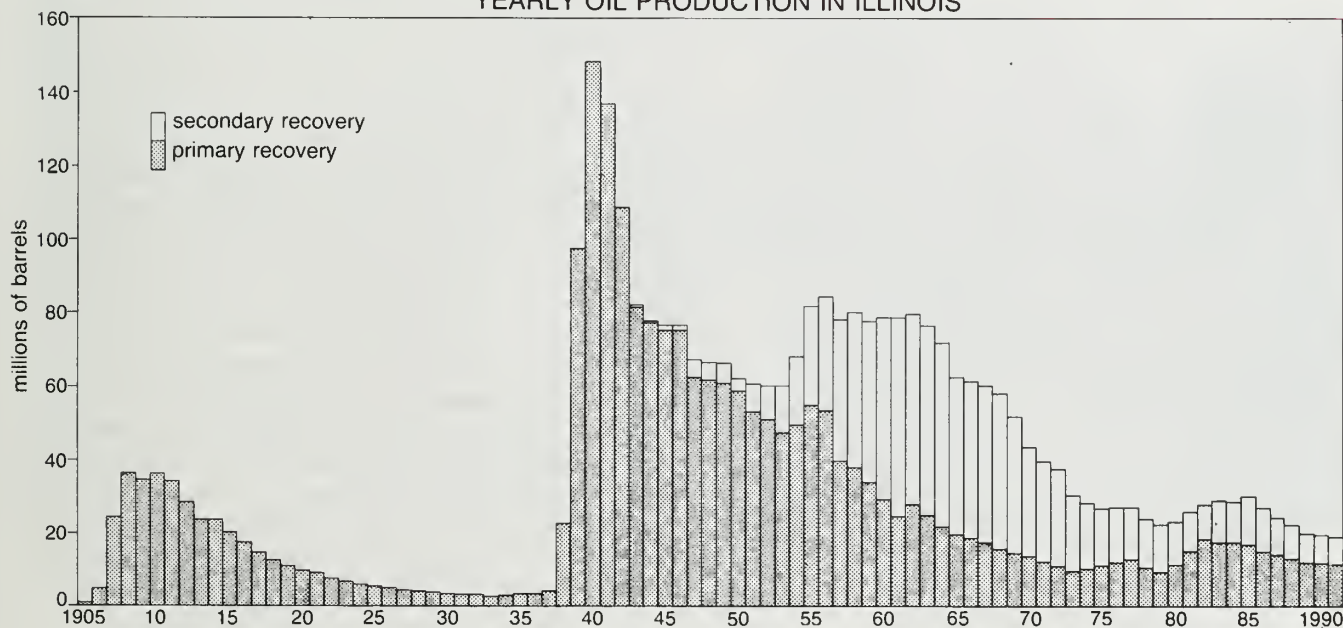
Impacts from Oil and Gas Research and Development

Past Numerous examples illustrate the impact of the Geological Survey's efforts on economic development and jobs in Illinois. While anecdotal, they nevertheless reflect the efforts over time of a developing group of experts, the utilization of an expanding and enhanced data base, and facilities developed to meet the technological requirements of the day.

Alfred H. Bell pioneered efforts to outline favorable areas for oil and gas. A 1930 geological map by Bell, which classified oil possibilities, indicated the deep part of the Illinois Basin, where there were no oil fields, was the most promising area for oil exploration. In 1937, Pure Oil Company discovered oil there, and production of oil in Illinois jumped from fewer than 5 million barrels in 1936 to nearly 150 million barrels in 1940. Bell's publications were widely used by industry during the heyday of the second peak period of oil production in the 1930s and '40s.

The figure below illustrates a number of periods of peak oil production in Illinois. The first peak resulted from the drilling of anticlines (arch of stratified rock in which the layers bend downward in opposite directions from the crest) following the introduction of the anticlinal theory of oil entrapment. The peak reached in the early 1940s was a result of the introduction of the seismograph used to map deep structures not known at the surface. Peaks in secondary production in the 1950s and '60s resulted from the introduction of other new technologies—water flooding and hydrofracing (water, under pressure, used to crack rock and, thereby, allow oil

YEARLY OIL PRODUCTION IN ILLINOIS



to flow better). The blip in production during the mid-'80s is a result of the price increase in crude oil that spurred on additional drilling.

The influence of the Survey during the development of oil and gas fields has been felt and recognized widely. Fred Squires, a well known petroleum engineer at the ISGS, described the suitable geological conditions for water flooding and assisted industry in the technical transfer of the developing technology into the oil fields in the 1940s. Calculations made in 1959 showed the extra oil, at \$3.00 per barrel, obtained by secondary methods influenced by Squires, had an annual value of \$120 million; and the cumulative value, resulting in part from his early efforts, is now many times greater.

As the number of records in the Geological Records Unit (GRU) increased (records are now available from more than 342,000 oil, gas and water wells and coal borings), knowledge of the subsurface also grew. At a meeting in Oklahoma City in 1963, Richard H. Howard, of the Illinois Survey, introduced a concept resulting from the discovery of the Wapella Field that led to the drilling of an estimated 1,000 additional exploration and development wells at a cost of \$10 million—a sizeable investment in Illinois.

A letter in the files of the ISGS recounted the efforts of a consultant who utilized records in the GRU plus the Survey's publications to develop a map of a structure in Brown County for a client. The structure was drilled leading to a discovery and additional developmental drilling in Brown County. Some 1.4 million barrels had been produced for that field by 1987, which, at an average valuation of \$25 per barrel, had an approximate total value of \$35 million. In addition, the drilling of more than 160 wells led to the infusion of approximately \$3 million into Brown County's economy and the state's tax base.



Requiring a large work area for his project, Donald K. Lumm, geologist, uses a table in the Geological Records Unit. Shelving in the background holds some 270 scout books containing historical and current information about wells.



Dr. Emmanuel O. Udegbumam, petroleum engineer, points out compartmentalization in a reservoir at King Field to Hannes E. Leetaru, petroleum geologist. The three-dimensional perspective was created on a graphics workstation.

Current This past year, the ISGS focused its efforts on a program to get more oil out of the ground from the oil fields already discovered. In its efforts, the Survey attracted nearly \$2.5 million into Illinois in matching federal funds from the U.S. Department of Energy (DOE) for a cooperative DOE/state project on Enhanced and Improved Oil Recovery. The immediate target of the research is to improve on the historic record of only 35 percent recovery from existing fields.

Some 5.9 billion barrels have been left behind in Illinois' reservoirs, either as mobile/by-passed oil, which, when identified, can be produced using technology that is economically attractive, or as residual immobile oil that may be produced only with great difficulty and at a price considerably higher than today's prices. Studies are under way in some 15 fields. This past year, an estimated 1 million to 2 million barrels were identified as mobile/by-passed oil in the King Field, producible by a combination of water flooding and strategic-reservoir-management practices. The ISGS is obtaining promising results from studies of other fields, all pointing toward strategic reservoir management as a key element to enhance the production of by-passed mobile oil. Should the program result in just 10 percent recovery statewide of the 1.5 billion barrels of by-passed mobile oil, at \$20 a barrel, some \$3 billion would be added to Illinois' economy. The size of the prize is significant.



In 1955, J. E. Hackett inspects the face of a gravel pit showing development of soil on sand and gravel outwash overlain by alluvial silts.

Impacts from Research on Minerals and Subsurface Mapping

Past Since its earliest days, the Survey has provided information to industry and private citizens on the locations of and exploration potential for mineral resources in the state, including both metallic and non-metallic minerals and industrial minerals such as sands, gravels, and aggregates for construction purposes. A statewide reconnaissance of local rock material resources was undertaken by the ISGS in 1929-'30 for the State Division of Highways. Maps, completed for most counties, are still valuable sources of information on the location of sand and gravel deposits and limestone exposures. Its studies of clay mineralogy, begun in 1931 under Ralph E. Grim, created new markets for clays, advanced the technology used in mining and manufacturing, and generated solutions to some problems in soil mechanics.

In the past, the Survey assisted materially in providing information for the development of the old lead-zinc district near Galena in northwestern Illinois and the fluorspar district near Rosiclare in southern Illinois. Long-term studies of fluorine chemistry were conducted to promote the nationally important deposits of fluorite, the state mineral. Begun in 1934 by Glenn C. Finger, research in fluorine chemistry resulted in the development of several new



In his fluorine chemistry laboratory in 1954, Glenn C. Finger sets up an experiment.

Technical editor Robert Wathen, left, accompanies John Nelson, geologist in basin and crustal analysis, through an abandoned tripoli mine. Two quadrangles, in which much of the tripoli mining took place, have been mapped to help discern the origin of minable tripoli.

fluorine compounds and practical techniques for producing them. Research demonstrated the unusual properties and suggested possible uses of these compounds, leading to their testing in industrial uses, drugs and pesticides at laboratories throughout the country. In fact, during World War II, the ISGS provided a fluorine compound, together with specifications for its preparation and purification, for the Manhattan Project's atomic bomb.

From its beginnings, the ISGS has been highly instrumental in the dramatic growth of the mineral industries in the state. The confidence of the state's leaders in the work of the Geological Survey became evident in 1933 when, despite sharp cutbacks in the budgets of all state agencies, a contingency appropriation was made



to the ISGS to preserve its research on Illinois' mineral resources. Emergency studies were also supported during the war years for oil and gas resources in the Illinois Basin, fluorspar deposits in Hardin and Pope counties, and lead and zinc in northwestern Illinois.

Statistics compiled at the ISGS valued mineral production in Illinois in 1905 at \$851.7 million in 1990 dollars. The value of Illinois' mineral production in 1912, based mainly on the production of 51 million tons of coal and 30 million barrels of oil, reached \$1.64 billion in 1990 dollars. That year, Illinois ranked third among the states in both coal and oil production. Illinois has held a virtual monopoly in the production of fluorspar in this country for most of this century. By 1950, the state's mineral production had climbed to about \$2.69 billion (1990 dollars) and \$2.38 billion (1990 dollars) in 1970. Nine years later, mineral resources yielded a value to the state of more than \$3.56 billion (1990 dollars) with Illinois leading the nation in the production of fluorspar and tripoli, being third in the production of crushed stone and peat, fifth in coal, sixth in sand and gravel, and 16th in oil and gas.

In much of its minerals work, the ISGS relied heavily on data accumulated and maintained through years of research. For example, when the Illinois Department of Transportation and the U.S. Railway Association (USRA) needed information regarding coal reserves adjacent to the Penn Central Railroad in Illinois, the data was readily at hand. The Survey reported that more than 12 billion tons of coal reserves lay within a 10-mile corridor along the railroad from Stonefort to Danville and from Paris to Decatur. This kind of information was critical to the state and federal agencies studying the future of the railroad in 1976. The ISGS' report led James R. Blaze, manager of strategic planning for the Railway Association in Washington, to label the Illinois report "perhaps the best technical presentation on coal reserve data that USRA has received."

Basic investigations of the mineral commodities of the state and applied research continued to get high priority: geologic mapping, stratigraphic studies, the development of improved chemical analyses, paleontology, and the like. And, while this work helped provide fundamental data required for the Survey's own research programs, the data generated were widely used by industry, other governmental agencies and the public.

One anecdotal account perhaps best portrays the impacts and value of the Survey's efforts. In 1987, Harry Temple, President of the Shakespeare Oil Company, wrote an open letter to the members of the Illinois Geological Society citing benefits derived from information provided by the ISGS. He reported that in about 1972, his company used a bulletin published by the Survey that showed the overburden thickness in and around Tuscola. Using this map, his company located the most likely spot for a quarry, the place where there was the least amount of overburden. "The result was the opening of a quarry at Tuscola by the Tuscola Stone Company." That particular location saved transportation costs of aggregate on the order of \$1.00 a ton for the users in the nearby area.

Temple estimated that the quarry is capable of producing between 250,000 and 500,000 tons a year, and that over a 50-year-life of the quarry, with an average tonnage of 300,000 tons a year, the cost savings for farmers, the county, and the state would be approximately \$15 million—just from the use of a single map produced by the ISGS! Temple noted that the pay back to the people of Illinois, the highway department, and the state represents a "very good return on the state's investment in the Survey."

Current The most recent total reported value of minerals extracted, processed and manufactured in Illinois rose to about \$2.92 billion in 1990, a 2.5 percent increase over the 1989 total. Minerals extracted accounted for 90 percent of the



Thirty-one years ago, Dr. John P. Kempton is shown plotting well control for bedrock surface maps. Today Kempton is senior geologist and head of the Quaternary Framework Studies Section.

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Studying an outcrop on I-57, Dr. Robert D. Cole, sedimentologist, left, Dr. Emmanuel O. Udegbumam, petroleum engineer, and Stephen T. Whitaker, geologist, discuss preparing fresh surfaces so they can take gamma log and permeameter readings. Gamma ray emissions from the rock are indicative of how clean the sands are.

Barbara J. Stiff, GIS specialist, Michael L. Sargent, geologist in basin and crustal analysis, and Dr. James W. Baxter, senior geologist and head of the Industrial Minerals and Metals Section, examine a map showing potential veins of fluorspar in Illinois. Assessment maps were produced digitally for the Paducah CUSMAP project.

reported value; crude minerals processed and manufactured minerals accounted for the remaining 10 percent. The number of people employed in the state's mineral industries went up to 120,500 in 1989 (the latest statistics), 3,500 above 1988 figures. Although jobs in mining declined, the increased employment in processing and manufacturing mineral products more than compensated for the loss.

Leading commodities continued to be coal and oil, followed by industrial and construction materials. Illinois produced six percent of the tonnage and about 7.6 percent of the value of the coal produced nationally. The state continued to lead the nation in the production of fluorspar, industrial sand, and tripoli. Production



of stone and sand and gravel were respectively 5.1 and 3.5 percent of the national total. Although the state's mineral production is currently up slightly, attributable to the steady growth pattern of industrial minerals that are local commodities in nature, during the last 10 years, the overall value of

mineral production has decreased because of the radical drop in oil prices, particularly in 1985 and '86, and the drop in coal prices accompanied by production stagnation, allowing the total value of coal to decline.

An area for hope may be the entire Paducah Quadrangle, a 7,500-square-mile area covering 5,000 square miles of 17 counties in Illinois south of the latitude of Benton and adjacent portions of Kentucky, Missouri and Indiana. Comprising one of the most mineral-rich areas in the world, this quadrangle was studied as part of the Conterminous U.S. Mineral Assessment Program (CUSMAP) of the U.S. Geological Survey (USGS) in cooperation with state geological agencies. This particular quadrangle was singled out for scrutiny because of its significant production of mineral resources and the potential it holds for future discovery and production.

Preliminary geologic maps, illustrating the potential for deposits of mineral resources in the quadrangle, were unveiled in January to 170 representatives of industry, governmental agencies and academia, constituting an economic release of the information to the public. Some 61 computer-generated maps, derived from the five-year detailed geological, geochemical and geophysical study of the quadrangle, will enable industries to assess the benefits of exploring in the area and can serve as the basis for environmental- and resource-related policy decisions by governmental agencies. Already a strong interest has been shown in this area by mineral explorationists.

This CUSMAP effort was the first to be completed using a Geographic Information System (GIS). The Illinois Survey's GIS enabled the scientists to produce computer-generated maps that readily outlined areas which may hold undiscovered mineral resources. As a basis for this evaluation, scientists compiled bedrock geology from 85 quadrangles; compiled and interpreted magnetic and gravity field data, depicting trends in magnetism of the rocks in the subsurface and the density of bedrock respectively; and digitized structural information from 290 drill holes, representing more than 500,000 total feet of drilling. In addition, geochemical information on anomalous metal values was obtained from more than 15,000 samples of insoluble residues derived from cuttings and core of 124 drill holes.

These data constituted the largest subsurface data set of any CUSMAP project in the country.

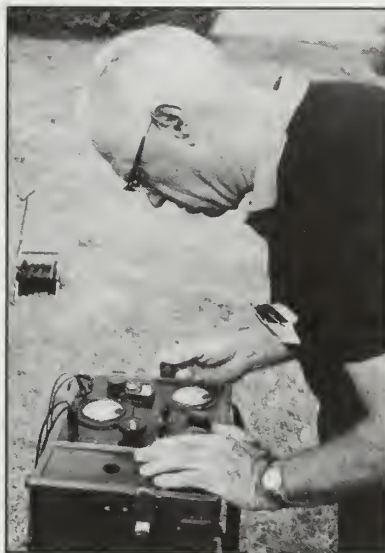
Geologists established and weighted diagnostic criteria for the potential occurrence of each type of mineral evaluated. They also considered mineral deposit types not known to exist in the quadrangle by comparing the Illinois Basin and its underlying structural systems with similar environments of known mineral deposition elsewhere. Undiscovered mineral commodities that have a high potential for occurrence in many southern Illinois locations include coal, oil, gas, fluorspar, lead, zinc, barium and other metallic minerals; plus limestone and dolomite aggregate, sand, gravel, tripoli and clay minerals. Numerous new data on potential, undiscovered fuel, metallic and non-metallic mineral resources in the Paducah Quadrangle will be made available to the public in forthcoming publications and open-file reports of the ISGS.

"Information provided by the Illinois State Geological Survey is critical for the health of the mining industry, since much of what the Survey does is regional in scope and far beyond the means of any one company," according to a mining exploration consultant in a recent letter to legislators. Citing the work done on the Paducah Quadrangle, he said, "As a company, we were able to provide valuable information, samples and access to our mines that aided in the generation of a regional geological data base. However, it was the effort and the funding of the various governmental agencies that brought the project to the point where it is today. The data generated by this one project alone will help my company and the mining industry in general for years to come."

Impacts from Research on Water Resources

Past An article in 1960 described the ISGS' success in the 1940s in helping Champaign-Urbana locate an additional water supply to supplement the two well fields then located north of Urbana. In 1942, the Survey began electrical earth resistivity surveys, a geophysical method of prospecting for water supplies in glacial-drift deposits. The article reported that the ISGS found the most favorable water-bearing deposits were likely to be west of Champaign, and by 1960, The Northern Illinois Water Corporation had located four producing water wells there.

Efforts to locate economic supplies of groundwater have continued using integrated geological and geophysical exploration techniques. Staff members at the Survey mapped buried Pleistocene paleovalleys in the 1980s, leading to the location of new supplies for municipalities in northeastern Illinois in the collar counties around the burgeoning greater metropolitan-Chicago area. Their efforts led to the location of supplies from shallow aquifers available at a pumping cost of \$.10 to \$.25 per 1,000 gallons compared to the cost of piping in water from Lake Michigan at a cost of \$3.50 to \$4.00 per 1,000 gallons plus the capital investment costs for the local communities.



In 1961, Merlyn Buhle operates a resistivity instrument used in ground-water resource work.

Edward C. Smith (left), geologist in hydrogeology, examines dune sands in a groundwater assessment project. Logging boreholes, Phillip G. Orozco (right), technician in hydrogeology, prepares to put a caliper tool down a water well.



Current During the past year, the ISGS, in cooperation with the State Water Survey, published a report on the groundwater resources in the Mahomet Bedrock Valley of eastern Tazewell County. The findings indicate that from 70 million to 75 million gallons of groundwater per day might be developed from aquifers in the area and that identified potential aquifers are capable of sustaining production at a rate of between 20 million and 50 million gallons of water per day.

The Geological Survey continues to supply services to individuals, farmers, and communities in locating water supplies and has been rewarded for its efforts utilizing electrical resistivity surveys with comments received in 1990 and '91 such as the following: A water well operator near Olney wrote, "The services...extended have been a huge benefit...." "It's a good well. Thanks for all your help...," were words of gratitude regarding a source of water found on a farm near Peoria. And "I am very happy with the results," was the response received for the Survey's assistance in locating a well in Marshall County.

Just this past year, staff members conducted electrical resistivity surveys at 51 locations, including 10 municipalities, two public water supplies, four industries, 18 farms, and 17 private acreages throughout Illinois. They also ran 42 borehole logs at 31 sites in the search for water-bearing sands and gravels.

Impacts from Research on Groundwater Protection and Waste Management

Past In recent years, while work has continued to locate water resources for communities and rural home owners, major efforts have also been directed toward protecting the resources. Even before and now in response to the federal Clean Water Act and the Illinois Groundwater Protection Act, the ISGS sought and is seeking ways to protect the state's groundwater supplies.

Those efforts had their beginnings in the early 1960s with a program in "environmental geology," a term coined by the Illinois State Geological Survey's staff. James E. Hackett, hydrogeologist at the ISGS, described that program as "the conscious application of geologic knowledge—to solve the problems in physical planning concerned with water resources, mineral-resource development, water pollution and contamination control; and all land uses that involve the nature of land." He noted that "the need for conscious application of geologic knowledge to problems of regional planning, development, and management is a pressing one and cannot be over emphasized."

Actually, the Survey was ahead of its time. The ISGS was performing significant geological and mineral resource investigations important to environmental problems long before many geological agencies throughout the world initiated programs in environmental geology. It had become obvious that certain practices in manufacturing, mining, transportation and urbanization produced undesirable impacts on water, air and land.

The siting of landfills and geology-for-planning studies became core issues for scientists at the Survey in the 1960s and '70s. Central to the thinking was the need to protect groundwater supplies, the lifeblood of many cities and farms.

Stack-unit maps to portray the nature and distribution of earth materials down to depths of 20 or 50 feet were developed by the ISGS' geologists. From these basic maps, earth materials were classified according to the potential of aquifers within a sequence to become contaminated. A detailed mapping effort in Boone and Winnebago counties, which was concluded in the early 1980s, is an example of the ISGS' approach. Other regional maps of the state were constructed on a scale of 1:250,000 or 1:500,000 during that decade for screening purposes to identify regions prone to contamination of groundwater and more recently to identify recharge areas for groundwater.



As part of an environmental site assessment, staff geologists Anne L. Erdmann and Michael S. Summers gather samples from which to detect volatile organic compounds and gases in the soil.



Myrna M. Killey, geologist in Quaternary framework studies, and Randy Locke, student intern, look at an interesting feature while measuring recovery of core drilled in the Cooperative Geologic Mapping (COGEOMAP) study of the Champaign Quadrangle with the U.S. Geological Survey (USGS). This project will develop methods for combining regional USGS mapping of thickness and character of Quaternary deposits with the ISGS' stack-unit mapping techniques and help set standards for state-of-the-art three-dimensional Quaternary mapping.

Such efforts have led to the recognition of the need for more detailed geologic mapping in Illinois at a scale of 1:24,000 for more site-specific studies related to the selection of the most appropriate, environmentally-sound location for building facilities such as landfills, industrial plants, dams, airports, bridges and roads.

Current The recognition and value of such detailed maps was clearly illustrated in a publication this past year which compared the benefits and costs of the

detailed mapping in Boone and Winnebago counties and projected those benefits and costs for the entire state. The study showed that through avoidance of clean-up costs alone, the benefit/cost ratio in the most likely case for Boone-Winnebago counties ranged between 12 and 27 with a present value in cost savings of between \$3.4 million and \$7.9 million. The value of such a program to the state was calculated to have a benefit/cost ratio of between 1.2 and 2.7 with a cost savings of between \$63 million and \$147 million, based only on saving clean-up costs through using such detailed mapping. Other benefits were not included such as the maps' uses for locating mineral and water resources or for planning highways, bridges and dams, or for classifying earth materials by their potential behavior during earthquakes or proneness to landslides and other natural hazards for which protective steps could then be taken to safeguard the citizens and businesses of the state and their investments.

The detailed maps have also been used in Boone and Winnebago counties by teachers to educate future generations about the environ-

ment and its geological connection. These students will be future planners, scientists and industrialists. Benefits of preparing them for a sound and healthy environment are immeasurable.

In addition, the benefit/cost study on geologic mapping has significantly (and in a timely fashion) supported the efforts to successfully pass federal and state legislation on mapping. President Bush signed the Geologic Mapping Act into law on May 18, 1992 calling for a national geologic mapping program with the USGS as the lead federal agency working in association with the 50 states. Support of the appropriation now is needed to implement the authorizing federal legislation, a key element of which is the State Geologic Mapping Component, calling for

matched state and federal funds.

Other current efforts could lead to safer yet economical ways to construct landfills or to safeguard rural water supplies. A 1991 publication of the ISGS described a prototype and large-scale soil liner constructed at the Survey, indicating that such liners can be built to meet the standards set by USEPA for saturated hydraulic conductivities.



On a display of geologic information prepared for decisions concerning the siting of landfills, Dr. E. Donald McKay, senior geologist and head of the Geological Mapping and Digital Cartography Section, discusses a three-dimensional model of Lake County with Robert J. Krumm, geologist. In the foreground is a map prepared for Champaign County.

While Dr. Keros Cartwright, principal geologist and head of the Hydrogeology Research Lab, tops off water in an evaporation pan at the clay liner, Ivan Krapac, geochemist, notes the activity.



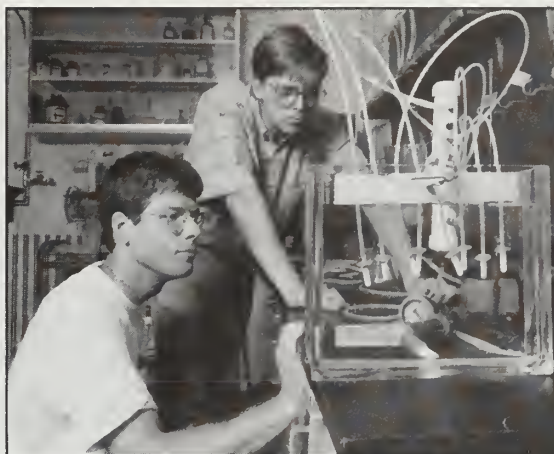
Contamination of groundwater by pesticides has been of great concern in recent years. Since 1979, more than 46 pesticides have been found in groundwater in the United States.

In a variety of hydrogeologic settings in Illinois, scientists have field tested and evaluated components of an experimental design for a proposed survey to assess the occurrence of agrichemicals in rural, private water wells. From this activity, cost-effective guidelines can be expected for a proposed statewide survey. In addition, such studies can affect the guidelines for construction of rural water wells and the application of pesticides to help ensure the health and safety of the rural population.

Pesticides applied to sandy soils are especially susceptible to leaching and subsequent contamination of groundwater. While investigating methods to reduce the movement of agrichemicals in such soils, the ISGS has found the use of some surfactants, to which pesticides stick, helpful in decreasing their leaching.

Remediation of pesticide-contaminated soil and groundwater at some 1,300 agrichemical facilities in the state is another research interest of staff members assisting the Illinois Department of Agriculture (IDOA) in responding to 1990 amendments to the Illinois Pesticide Act. Scientists are developing a strategy for assessing site conditions and operational practices at the facilities, working out a scientifically valid way of determining the extent of pesticide contamination in soil, developing procedures and data bases for locating the best areas in which to collect soil samples to ascertain the degree of subsurface contamination, and summarizing remedial technologies and their cost effectiveness.

In support of the state's Pesticide Management Plan being developed by IDOA, statewide geologic mapping has been used to identify regions with aquifers vulnerable to contamination by agricultural chemicals. A state map at a scale of 1:500,000 and a map for each county (1:250,000) were prepared. Areas with intensive corn and soybean production and aquifer materials within 50 feet of the earth's surface are most vulnerable to contamination. In approximately 40 percent of rural Illinois, aquifers lie within 50 feet of the surface. These shallow aquifers occur throughout the state but are most common in the northern and southern parts of Illinois and along the major river valleys. In about 60 percent of the rural area, aquifers are more than 50 feet deep and apparently are protected from pesticide contamination by the attenuation capacity of soils and thick sequences of fine-grained materials. The study of these maps showed that pesticide use, largely for corn and soybean production, is heaviest in areas where aquifers are generally least vulnerable to contamination.



Damon Garner, graduate student, left, and Donald A. Keefer, geologist in groundwater protection, determine the pressure value for each ceramic cap on the tensiometer. This equipment, used in the field to monitor water movement through unsaturated soil, is useful in pesticide studies.



At an agrichemical facility, Dr. Michael L. Barnhardt, geologist, describes a core sample, which will be tested for pesticides and physical properties.

In yet another study, scientists are looking at groundwater's contributions to loadings of atrazine and the products of its degradation in streams by investigating their subsurface movement in a small watershed. Ultimately, an understanding of the way in which pesticides enter surface water may lead to better management practices that will minimize surface-water contamination by agrichemicals.

Impacts from Research on Earth Hazards and Engineering Geology

Past The Geological Survey has been involved with the application of geologic knowledge to problems connected with man's use of the land. Major early efforts were related to the identification of safe dam sites and favorable locations for highways, utilizing a combination of topographic maps and geologic information.

In 1927, for example, the year in which the Engineering Geology Division was formed, records show a state highway engineer noted the new location of a highway that came from the topographic map "shortened the route by at least a half a mile which meant an actual savings in construction of 17 [thousand dollars] or 18 thousand dollars...." Think what that savings would be for highways today!

In the 1970s, the Survey helped to establish the Mine Subsidence Insurance Fund and has continued to provide information on the location of mined-out areas to insurance companies to assist them with processing claims. In addition, the ISGS has given information to private citizens and others inquiring about any possible problems related to potential mine subsidence from former or current underground mining activities. Concern about the pollution of Lake Michigan and shore damage caused during a period of high lake levels in the early '70s and again in the '80s led to studies of bottom sediments and shore processes which affect human activities along the shore. In the 1980s, landslide-prone areas were addressed in a special publication.

Also in the 1980s, the Survey provided information to the Department of Commerce and Community Affairs (DCCA) and to a Japanese and American team

seeking to locate a Chrysler-Mitsubishi plant in Illinois. The team found details on foundation conditions, proximity to mined-out areas, and sources of water supply to be extremely helpful and undoubtedly influenced their decision to locate the manufacturing facility near Bloomington-Normal.

Current In the past year, the ISGS published information on the proximity of underground mines to residential and other built-up areas in the state. Inasmuch as this document identified some 178,000 acres of residential and other built-up areas as being in close proximity to underground mines and, therefore, possibly exposed to subsidence, the publication is expected to have far-reaching effects on

In conjunction with a mine subsidence project of the U.S. Bureau of Mines near Rend Lake, Dan Van Roosendaal, geological engineer in earth hazards and engineering geology, logs core from a borehole. The ISGS also tests the core for rock strength and rock mechanics.



planners, developers and homeowners in their considerations regarding future building locations, building designs and insurance needs.

The value of the Survey's engineering data base and expertise was also recognized during the recent Chicago flood. Within 24 hours of a call for help, scientists and engineers from the ISGS were in Chicago discussing the information contained in their files on the nature of the earth materials in which the flooded tunnel was located. Using a 1954 report and other information on file, the Survey's staff members, in cooperation with the Illinois State Water Survey, were able to point out that the tunnel was located mainly in saturated, firm clay with low hydraulic



Samuel V. Panno, geochemist in groundwater protection, is measuring water levels in a piezometer at a fen while studying the effects of urban development on surrounding wetlands such as the changes in water chemistry brought about by the installation of septic systems.

conductivity, supporting the idea that the tunnel could be rapidly de-watered without collapsing or inducing failure in the foundations of nearby structures. Rapid de-watering, of course, meant a more rapid return of businesses and industry to their normal operations and a less severe economic impact. Lessons demonstrated by this exercise were: 1) that data bases properly stored and maintained have tremendous value, even if they are decades old; and 2) their use and application can only be realized by maintaining a corps of trained experts (scientists and engineers) who know where the data is and what it means so that the information can be rapidly applied when and as needed.

With an eye on the future, the ISGS, in cooperation with other divisions of ENR, is helping to evaluate the availability of data and develop procedures for using those data and the GIS to assess environmental trends in the state. Goals of this assessment are to understand the current condition of Illinois' natural and man-made environment, determine which aspects of the environment are changing and in what manner, and develop mechanisms for assessing the trends which appear to be causing or have the potential to cause significant problems. Armed with this information, the state can design and apply remedial actions in the most effective and efficient manner. Illinois' large GIS system will be a major tool for this study.

Outlook for Future Positive Impacts from ISGS' Research and Development Efforts

At this time, detailed geologic mapping at a scale of 1:24,000 for the state, coupled with ongoing research and development efforts in coal, oil and gas, minerals, water resources, groundwater protection, siting of facilities, and geologic hazards, offer major opportunities for future enhancement of Illinois' economy, the creation of jobs, and cost-effective measures for environmental protection. With added support, the future for focused activities in these areas will be bright.

A Final Thought

Accomplishments such as those just cited are the result of efforts by unbiased scientists conducting credible research. Indeed, the knowledge gained and dispersed means better educated citizens in the public, private and governmental

sectors. With better knowledge and understanding of our surroundings, citizens should find less need for costly regulations, especially those that are not cost effective. It is time that the public and governmental authorities awoke to the fact that Illinois' scientific agencies and their parent, the Department of Energy and Natural Resources, have and can continue to provide information, technology, ideas and knowledge of value to mankind at least equal to, if not greater than, the value provided by regulatory or welfare agencies and, hence, should be supported with at least equal fervor.

If ever there were a time for scientific investigations and technology development to promote wise economic development, jobs, and environmental protection, that time is now! A major effort is required to create ideas, environmentally-sensitive technologies, incentives and knowledge—not costly regulations and disincentives.



David L. Reinertsen, at right, senior staff geologist, acquaints participants on a field trip with the geology, mineral resources, and environmental setting of an area in northwestern Illinois.

From the Kudos Files: Appraisals by Supporters

In this year alone, during a budgetary crisis, a number of individuals relying on the Survey's information and services have expressed the need to keep the ISGS a strong, state-supported scientific institution. Among comments are those of a consultant who has been active more than 40 years in coal resource development in this country, Canada and the United Kingdom, who wrote, "If we are to retain our Illinois coal industry and reduce or remove our needs for imported coal from the west, we need the good services provided by the Survey."

In the words of the president of an oil company in Illinois, "The Geological Survey...in seeking improved and enhanced oil recovery in Illinois by reservoir characterization made substantial improvements in the services that they can offer.... I can tell you that the Wapella Field near Clinton wouldn't be there if the Survey hadn't had the information that was given to the geologist, which was the basis for its discovery. That field has made about 3.2 million barrels. I can tell you that the limestone quarry at Tuscola, just off Interstate 57, wouldn't be there if the Survey hadn't released the information that triggered its development. I know of many oil development projects that wouldn't have happened if the information hadn't been available at the Survey."

Personnel of the Survey provide the "scientific and investigatory expertise and compile and maintain the data bases in which the science and investigations are grounded to support a myriad of state, federal, educational and private organizations responsible for protecting and/or providing groundwater, other natural resources, crops, food sources, public infrastructure, and a safe environment. No matter how low profile their work, it is vital... There is a direct correlation between the level and competence of this public scientific support and the success of the organizations that protect our environmental health, design and build our roads and landfills, and provide the natural resources on which we depend for our standard of living.... My colleagues and I depend on these scientists in order to perform our jobs, also important public services," wrote a professional geologist with a federal agency.

"I find the information and resources provided by the ISGS...to be invaluable," said a registered professional engineer in a letter to the governor. Continuing he said, "Because geology and the earth sciences have



While Philip C. Reed, geologist in hydrogeology, checks spring water at Salt Springs, Dr. B. Brandon Curry, geologist in groundwater protection, sieves for snails and ostracods, which are microcrustaceans specific to different aquatic environments.



Data gathered from the experiment Dr. Steve Sim, petroleum engineer, is conducting in the pressure, volume and temperature apparatus simulates oil-production conditions in the laboratory and is used for reservoir and production engineering.

such a large impact on civil engineering related projects, information provided...is extremely helpful in the planning of projects. For example, in the preliminary design stages of a project, geologic information can be obtained from the ISGS prior to initiation of any detailed field investigation. This information will identify the expected geologic conditions in the project area and any conditions that may adversely affect the project. Because of this [information], field investigations can be planned more efficiently and more cost effectively and, more importantly, alert the designer/engineer to any geologic conditions that may adversely impact a project prior to its start up. This saves both time and money."

The head of a Michigan firm stated, "As a consultant, I usually rely on state geologic survey personnel and their reports for information to help clients in the mining industry within that state. The Illinois State Geological Survey is one of the better organizations with respect to the expertise of the professionals and the reports they publish. The quality of the staff and their work is an asset to the Illinois mining industries and those of us outsiders who rely on the Survey also.... The

Illinois legislature had the wisdom to establish a superior Geologic Survey which I believe has paid dividends to the State through its service to the mining industry."

According to a geologist and corporate user of the services of the ISGS, "We have in the past found on numerous occasions that their [the ISGS'] contributions have provided basic and fundamental information which has been critical to the development of natural resources within the state. The availability of the total data base of information on hand at this state agency is information which would not otherwise be available even through the expenditure of corporate funds for exploration and mineral development. It is the accumulation of both a data base of information which has been compiled over a period of many years, plus the significant contribution made through the knowledge and experience of the highly competent and professional staff of this agency.... The State Geological Survey stands out as being exemplary when compared to other state and federal organizations in terms of professionalism, experience and quality of data that they have available.... We are...expanding our involvement in the natural resource industry and...cannot properly develop mineral resources in an environmentally sound manner without their [the ISGS'] input."

Geologists Dr. Janis D. Treworgy and Stephen T. Whitaker work on cross sections for the Illinois Basin Consortium, comprising the Illinois, Indiana and Kentucky Geological Surveys that are working toward a better understanding of the basin through exchanges of information and cooperative basin-wide studies.



"Having spent a lot of time and money exploring for oil and gas in the state of Illinois, we can tell you our successes are due in no small part to assistance from the Illinois Geological Survey," noted an executive of a California oil and gas company. Continuing, he said, "Since our exploration office and...Illinois are separated by some 2,000 miles, it is essential for us to have enough competent staffers at the ISGS to retrieve and copy records.

Other services we use include discussions with qualified professionals who also publish geologic studies that small independent exploration companies have neither the time nor money to complete. Our company finds operating in the state of Illinois very favorable. We also believe it doesn't hurt the local economy when we spend money leasing land, drilling wells, lodging and eating in local establishments...."

A village administrator extolled the work the Survey has provided in "establishing the town's ground water protection areas, locating as economically as possible additional potable water sources, and generally giving them the geological advice and help desperately needed as a small developing community."

Proclaiming the virtues of the ISGS, a mayor wrote that the Survey provides "the day-in, day-out scientific expertise for intelligent decisions by both state and local government. In this respect, the Geological Survey was utilized by the Intergovernmental Solid Waste Disposal Association...to seek an optimal landfill site—no easy task, even with good scientific information...."

A county building and zoning department has had several contacts with the State Geological Survey the past several years. Describing the services received, the department's director said, "A scientist employed by the ISGS as a hydrogeologist served the county board as a consultant during lengthy hearings concerning the siting of a landfill. Her assistance was very valuable. The department [ENR] is currently working with county staff in preparing the base screening criteria for the eventual siting of a new landfill. This is a very valuable service provided local governments who do not have that sort of expertise or scientific equipment readily available to them. With the increased awareness of environmental problems that continue to surface around the state, it is important that Illinois' only scientific arm remain functional.... It is the state's responsibility to adequately support the researcher and program seeking scientifically-sound solutions to environmental stresses facing Illinois' citizens today."

A professional engineer, practicing in Illinois the last 16 years, is gratified at the professionalism of the Geological Survey. "I have personally used it as a resource for both information and advice on a variety of engineering projects. From my experience, such resources are invaluable for stimulating new projects and economic development in our state. The ISGS is currently regarded as one of the finest in the country. They have provided timely and practical information in the critical fields of groundwater resources, mineral resources, and land use planning. Because of the work of the Geological Survey, the regulatory programs associated with the Illinois Groundwater Protection Act have an extremely practical and effective technical basis which will help guide our state through a very difficult and critical problem. In addition, without the help of the ISGS, our current environmental regulations would not have advanced to meet the U.S. EPA's current rigid requirements. We can be thankful to the Illinois Geological Survey for providing technical support and professionalism to our regulatory programs."

The Survey's aid to communities is described by a consultant in this manner: "The ISGS has been very helpful to Northern Illinois communities in providing services and information. All of the governments that we represent...have utilized



Beverly L. Herzog, senior hydrogeologist and head of the Hydrogeology Section, bails a monitoring well at a landfill prior to sampling for volatile organic chemicals.

Contract drillers at an agrichemical facility are taking core samples that will be used to determine pesticide contamination of soil and water at this location.



the Geological Survey, including the electric resistivity studies that determine the exploratory work for groundwater. The Geological Survey has also furnished background data for groundwater recharge, soils strata for a variety of public purposes, and consultation for the efficient expenditure of local governmental funds."

The ISGS supports industry at a time when the industry of Illinois requires the Survey's information to recover economically, and government and industry require the Survey's information to avoid costly environmental errors, according to a former Chief of the Survey. Case in point..., during the Great Depression, the budget of the ISGS was increased 50 percent by the legislature and governor rather than decreased. "Information provided by the Survey has led to significant investment in Illinois for decades.

In the oil and gas industry, Survey studies have led to the new discoveries that have provided large additions to Illinois' state tax base. The Survey's current programs with the U.S. Department of Energy (DOE) are providing information that will allow the oil and gas industry to forego the abandonment of many wells, thus maintaining Illinois' tax base, and are providing new information that will allow us to improve and enhance oil recovery, thus increasing the tax base."

"The Geologic Survey...provides critical services to the mineral aggregates industry," according to the director of technical services of one large company. He wrote, "The Survey provides data that is vital to ongoing operations. A very important current effort is the geologic remapping, which will have a bearing on how efficient and competitive we are with producers from other states. The Survey, through other intelligence and information, further assists our industry in optimum

Working on a roadcut on I-57, petroleum engineers Dennis J. Haggerty, left, and Dr. Emmanuel O. Udegbumam take mini permeameter readings, measuring the ability of fluids to move through the rocks.



use of Illinois' resources. Recently, the Survey assisted us in developing a strategy to keep a sizeable portion of business in Illinois against import from an adjacent state."

Another vote of confidence came from Minnesota. "As a professional geologist with over 40 years experience in the minerals industry, as a past president of the American Institute of Professional Geologists, and based on my having utilized the services of many different state surveys, I know that the Illinois Geological Survey has long been in the forefront of such organizations in terms of effectiveness, quality of work and public service. Now, more than ever, there is an urgent need for good basic science required for realistic and cost-effective management of our natural resources and environment. This fact alone makes the Illinois Survey of prime importance to the people of Illinois and the nation."

A coal company executive in Illinois wrote, "The need to understand, protect and develop the state's mineral and ground water resources increases each year, and the ISGS...has provided a source of technically sound, unbiased information on which industry, community

planners and regulatory agencies can rely. The mineral industry, second only to agriculture in producing jobs and economic activity in the state, depends on the Geological Survey for technical support in geological and environmental evaluations and for important research in finding ways to utilize the state's huge coal reserves in an environmentally responsible manner. The environmental implications of landfill siting, hazardous waste disposal and ground water protection are the appropriate province of state government. They cannot be accurately evaluated without a strong geological effort...."

...the Survey's sentiments succinctly expressed.



Staff members from the U.S. Geological Survey prepare equipment for drilling while geologists Anne L. Erdmann, in the background at right, and Myrna Killey discuss drilling progress on the COGEOMAP project taking place in the Champaign Quadrangle.

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